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AN INDUSTRIAL WASTE GUIDE TO THE MEAT INDUSTRY

Public Health Service
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an Industrial Waste Guide to the

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Meat Industry

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service

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an Industrial Waste Guide to the

Meat Industry

Prepared by the
Committee on Meat Packing Plant Waste Disposal
of the American Meat Institute
in cooperation with the National Technical
Task Committee on Industrial Wastes

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service **Bureau of State Services**

I

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II

Foreword

In the Meat Industry, as in many other industries, control and disposal of wastes is a major concern of many plants. Optimum utilization and reduction of wastes is essential for most economic production in small as well as large plants. Wastes which cannot be eliminated must be disposed of in a suitable manner. Protecting the Nation's limited water resources for maximum use is mutually beneficial to industry, other special groups, individual citizens, and the Nation as a whole. In recognition of this fact, industries are paying increasing attention to the disposal of their wastes in a manner which will not impair the utility of stream waters for other beneficial uses.

This publication is a revision of "An Industrial Waste Guide to the Meat Industry." The original guide was prepared by the United States Public Health Service and published in supplement D of the report entitled "Ohio River Pollution Control" in 1943.

The Committee on Meat Packing Plant Waste Disposal of the American Meat Institute has suggested some changes in the original Guide in order to bring it up to date. These changes were submitted to the Public Health Service through the Meat Industry representative on the National Technical Task Committee on Industrial Wastes.

The National Technical Task Committee is composed of representatives from the Nation's leading industries concerned with solving difficult industrial waste problems. The objective of the organization is to perform technical tasks pertaining to industrial wastes in cooperation with the Public Health Service and all others concerned with improving the quality of our water resources. The preparation of this revision was one of the tasks assumed by the Meat Industry in carrying out this objective.

This is the second of a series of Industrial Waste Guides which will be prepared by the National Technical Task Committee in cooperation with the Public Health Service.

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An Industrial Waste Guide to the

Meat Industry

Introduction

This publication represents the efforts of waste technologists of the Meat Industry and others to develop a concise practical Guide for operating and design personnel. Reduction of wastes at their source is the initial objective of control measures. Appreciable reduction of waste can be accomplished through waste prevention measures carried out within the meat processing plant.

The section on waste treatment is not intended to be a comprehensive discussion of meat processing waste treatment. Sufficient information on waste treatment is included to suggest possible methods of solution to stream pollution problems which cannot be eliminated or adequately corrected by waste prevention procedures. Some performance data are presented on the more usual as well as the more recently developed meat processing waste treatment processes. This section will also serve to emphasize to meat plant supervisory personnel the value of waste saving methods in reducing total waste treatment costs.

The wastes from stockyards, slaughterhouses, and packinghouses are similar chemically to domestic sewage but are considerably more concentrated. The principal deleterious effect of these wastes on streams and other bodies of water is their deoxygenating effect.

Stockyard wastes contain animal excreta, and the amount and strength of the waste varies considerably, depending upon whether the pens are covered, the presence or absence of catch basins, practice in manure removal, frequency of washing, etc.

Slaughterhouses are establishments for killing and dressing of meat. Relatively little processing of the meat or of byproducts is done. Most slaughterhouses are relatively small, although a few in the larger cities may kill several hundred animals per day.

Packing houses are equipped to process the meat and byproducts to a much greater extent. The amount of processing varies considerably from plant to plant, resulting in wide variations in volume, strength, and chemical characteristics of effluent discharged to the sewers.

Description of Process

Slaughterhouse

The slaughterhouse or abattoir is principally a killing and dressing establishment doing little processing of byproducts. The finished product of the slaughterhouse is the fresh carcass, plus a few fresh meat byproducts such as hearts livers, and tongues.

The process consists briefly of sticking and bleeding animals on the killing floor, cattle being stunned prior to sticking. Carcasses are trimmed, washed, and hung in cooling rooms. Livers, hearts, and kidneys are sent to the cooling rooms to be chilled before being marketed. Hides, skins, and pelts are removed from the cattle, calves, and sheep and are salted and piled until shipped to tanners or wool processing plants. Viscera are removed and sent to rendering plants, along with feet and head bones. The feet and head bones may also be sent to glue

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works. Many slaughterhouses are now equipped to do their own rendering of inedible offal into tallow, grease, and tankage.

Packinghouse

Packinghouse killing floor operations are, in general, carried out with more attention to recovery of salable products. Carcasses are trimmed, cleaned, and cooled much the same as in the slaughterhouse, except that the packinghouse further processes some of the meat by cooking, curing, smoking, and pickling. Some of the operations conducted, in addition to those concerning processing of meat cuts, are: Manufacture of sausage and canning of meat; rendering of edible fats into lard and edible tallow; the cleaning of casings; the drying of hog hair; and the rendering of inedible fats into greases and inedible tallows.

The packinghouse is also equipped to process to varying degrees the "byproducts" which a slaughter house ships out as raw byproducts. Blood is usually collected, coagulated, and dried for edible and inedible uses. Tanning, wool pulling, and manufacture of glues, soaps, and fertilizers are, in general, carried on by separate plants.

Raw Materials and Product

The average weight of animals slaughtered in the United States in 1950, according to the Bureau of Agricultural Economics, United States Department of Agriculture, is as follows:

Animal	Weight on hoof	Dressed weight [1]
	Pounds	*Pounds*
Cattle	949	512
Calves	210	[2] 117
Hogs	240	[3] 135
Sheep	95	45

[1] Not including edible organs.
[2] Hide off.
[3] Excluding lard.

Approximate yields of total meat products and byproducts are:

Classification	Percentage of live weight			
	Beef	Veal	Pork	Lamb
Edible	60. 1	58. 9	75. 8	53. 9
Inedible	10. 3	10. 1	3. 7	17. 6
Shrinkage [1]	29. 6	31. 0	20. 5	28. 5
Total	100. 0	100. 0	100. 0	100. 0

[1] Moisture loss from processing fats, bones, blood, and curing and smoking operations, and valueless material such as viscera contents.

Source: Supplement D, Industrial Waste Guides, United States Public Health Service 1943.

The chief product, the carcass, is marketed in various cuts of fresh, smoked, cured, pickled, and canned meats, the slaughterhouse confining its production to fresh meats while the packer produces the full line of processed meats.

The byproducts of the slaughterhouse generally consist of cured hides, skins, and pelts, inedible tallows, animal feeds, miscellaneous fresh offal (collected by specialty houses).

Packing house byproducts are very numerous. Some of the principal byproducts are as follows (products or uses shown in parentheses are not necessarily processed at the packinghouse):

(*a*) ***Edible fats.***—Oleo stock, oil, and stearine; edible tallow; lard.

(*b*) ***Inedible fats.***—Tallow; grease; neat's-foot stock.

(*c*) ***Hides, skins, pelts (pulled wool).***

(*d*) ***Tankage, meat scraps and stick.***

Employee: Raw Material Ratio [1]

Number of plants considered	Plant	Type kill	Number of employees	
			Per 100 head per day	Per 1,000 pounds live weight per day
23	Slaughterhouse	Mixed	31	0. 70
7	Packinghouse	do	37	1. 18
7	do	Hogs [2]	37	1. 62
7	do	Sheep [3]	5	. 36

[1] Data obtained from survey of Ohio River meat processing plants conducted by United States Public Health Service in 1939 and 1940.
[2] Hogs constitute 90 percent or more of total kill by number.
[3] Sheep constitute 88 percent or more of total kill by number.

(*e*) ***Dried blood.***—(Blood albumin).

(*f*) ***Bone and bone products.***—Steamed bone meal; cooked bone meal; dry bone.

(*g*) ***Hog hair and bristles.***

(*h*) ***Horns and hoofs.***

(*i*) ***Intestines.***—Sausage casings; (tennis and musical strings, surgical ligatures).

(*j*) ***Glands.***

Sources and Quantity of Wastes

Sources of Waste

Practically every operation connected with this industry is a source of waste through discharge of process liquids and wash waters.

The chief sources of waste are as follows:

Stockyards.

Slaughterhouse: killing floor; carcass dressing; rendering; hide cellar; cooling room.

Packinghouse: killing floor; carcass dressing; rendering; hide cellar; hog hair removal and processing; casing cleaning; tripe room; laundry; glue, soap, fertilizer.

Table 1 shows approximate flows, analyses, and strength of waste for the 3 types of establishments. Tables 2 and 3 give unit packinghouse losses and variations in such losses.

TABLE 1.—*Approximate range of flows, analyses, and waste loadings for stockyards, slaughterhouses, and packinghouses*

Operation	Unit	Waste flow gallons per unit	Typical analysis parts per million		Waste loading in pounds per unit	
			Biochemical oxygen demand	Suspended solids	Biochemical oxygen demand	Suspended solids
Stockyard	Acre	23, 070–36, 600	64–100	[1] 175	[1] 13. 4	[1] 36
Slaughterhouse	1,000 pounds live weight	435–1, 100	650–2, 200	930–12, 000	8. 4–20. 0	3. 5–11. 0
Packinghouse	1,000 pounds live weight	750–4, 350	100–3, 000	233–720	5. 2–23. 5	2. 9–22. 1

[1] Only 1 value available.

Table prepared from data from various sources including technical literature and private correspondence.

TABLE 2.—*Unit packinghouse losses*[1]

[Pounds per 1,000 pounds of live weight]

Type	B. O. D.	Suspended solids	Nitrogen	Grease
Hogs	18. 0	12. 0	2. 67	0. 90
Do	15. 0	9. 1	1. 29	2. 30
Mixed	12. 7	4. 6	2. 02	1. 44
Hogs	13. 1	9. 8	1. 25	2. 83
Cattle	20. 8	14. 8	2. 24	. 68
Do	15. 7	14. 8	2. 01	1. 79
Do	10. 5	10. 0	1. 02	1. 00
Mixed	19. 7	9. 4	2. 59	. 60
Hogs	9. 8	7. 2	1. 46	. 27
Mixed	16. 7	15. 0	2. 18	2. 00
Cattle	10. 0	11. 0	1. 08	. 55
Mixed	14. 7	13. 2	1. 70	1. 5
Do	6. 5	6. 2	. 79	. 5
Do	19. 2	11. 2	2. 10	2. 1
Do	8. 9	10. 8	. 89	
Do	21. 6	21. 7	1. 82	6. 0
Average	14. 6	12. 0	1. 70	1. 63

[1] Adapted from a presentation by F. W. Mohlman at the Conference on Research of the American Meat Institute, 1949.

Quantity of Waste

Stockyards.—The volume of waste from a 27-acre section of the Chicago stockyards for a 12-hour day flow was 0.623 million gallons or 23,070 gallons per acre per 12-hour day.

Slaughterhouses.—Carcass washing and general cleanup washes are the principal sources of slaughterhouse wastes. No information has been found to furnish a complete breakdown of the volume of waste from the component operations of the slaughterhouse.

Packinghouses.—Some reported volumes of packinghouse wastes are shown in table 3.

TABLE 3.—*Variation in unit losses between packinghouses* [1]

[Per 1,000 pounds of live weight]

Plant	Gallons of waste	Pounds of B. O. D.	Pounds of suspended solids	Pounds of organic and ammonia nitrogen	Years of data
A	1,300	12.7	4.6	2.0	
B	1,400	19.7	9.4	2.6	
C	2,300	16.7	14.9	2.2	
D	3,250	14.7	13.2	1.7	
E	1,300	6.5	6.3	.8	
F	4,350	19.7	22.1	2.1	
G	1,370	8.0	10.4	1.0	
H_1	750	16.0	20.0		1937
H_2	1,100	10.7	9.1	1.2	1949
I_1	1,250	23.5	16.2		1934
I_2	1,080	11.8	12.0	1.6	1950
J^2	1,800	20.0	11.0		

[1] Adapted from a presentation by Hill at the American Meat Institute's annual meeting in October 1950.
[2] Slaughtering only.

Character of Wastes

Stockyards

Stockyards appurtenant to packing plants are ordinarily provided with catch basins and are usually floored and sometimes covered.

Wastes consist of water trough overflow, liquid excreta, and pen wash waters containing manure.

Uncovered pens are subject to flushing in rainy weather with consequent leachings from manure and carrying over of manure itself to the sewer.

The character of these wastes would be expected to vary widely, dependent on the presence or absence of catch basins, practice in manure removal, frequency of washing, etc.

An analysis of the wastes from a Chicago stockyard is as follows:[1]

Determination	Concentration (parts per million)
Total suspended solids	173
Volatile suspended solids	132
Organic nitrogen	11
Ammonia nitrogen	8
5-day biochemical oxygen demand	64

[1] From Supplement D, Industrial Waste Guides, U. S. Public Health Service, 1943.

Slaughterhouse

Killing floor.—Many houses save blood for sale to rendering plants or to fertilizer manufacturers. Some small houses use part of the blood to add to their tankage and sell or give away the remainder. This decreases substantially the oxygen demand and the color of the effluent discharged to the sewer.

Paunch manure is usually segregated from the liquid wastes and disposed of separately. At some of the rural plants, it is hauled away by farmers for soil conditioning. A number of the city slaughterhouses dispose of paunch manure with garbage. The separate disposal of paunch manure reduces materially the settleable solids in the effluent entering the sewers.

Floor washes contain blood, manure, flesh, and fat particles.

Carcass dressing.—Carcass washes contain blood, flesh, and fat particles from trimming.

Rendering.—Many slaughterhouses render offal for inedible tallows and tankage. Where wet rendering is practiced, tank water remaining after grease and residue are taken off is further processed into tank-

age. Processing of tank water reduces substantially the biochemical oxygen demand and the solids content of effluent discharged to the sewer. Larger plants evaporate this tank water to produce a thick residue, called "stick," which is mixed with the tankage. Nearly all the smaller plants have installations of dry rendering and produce no tank water because any water charged into the melter is evaporated.

Inedible raw material is prepared for rendering by hashing and washing. This operation adds a considerable quantity of residue to the effluent. This residue consists of small flesh and fat particles and intestinal contents. Where the steam rendering process is used, the pressing of the residue into cakes produces additional tank water. This liquor is usually added to the stick evaporator feed.

Wash waters, both floor and equipment, from tank rooms contribute varying amounts of pollutional material, depending on the care exercised in handling materials and on general cleanliness.

Hide cellar.—Green hides are chuted to the cellar from the killing floor. Here they are piled flesh side up and sprinkled with salt. A small amount of drainage from these piles, in addition to floor wash, goes to the sewer.

Hog hair removal.—Hair is loosened in a scalding tub or vat and removed by scraping. Discharge of vat waters and scrapings contribute hair, dirt, and scurf from the hog skin.

Cooling room.—Liquid wastes draining from this unit are of minor significance. Some houses use sawdust on the floor, which is swept up periodically.

Some analyses of combined slaughterhouse wastes for a small plant, which were obtained during a 2-day survey to determine the effectiveness of the plant's waste treatment installation, are given below.

The kill operations in the plant on the survey dates were as follows: September 22, 15 cattle; September 23, 5 cattle, 4 lambs, and 27 hogs. The volume of wastes was 4,200 gallons per day on the twenty-second and 3,070 gallons per day on the twenty-third.

Packing Plant

Carcass dressing.—This operation is, in general, similar to that carried on in the slaughterhouse. Wash wastes are discharged into catch basins, and the grease is recovered.

Rendering.—The larger packing houses do both edible and inedible rendering and make use of various rendering processes, including steam and dry rendering and low temperature rendering. Fats are hashed and washed prior to being discharged into the rendering vessels, and the wash water is discharged to lines running to a catch basin where the fats are recovered and the heavier materials are separated from the effluent. The condensate from the steam rendering produces a liquor containing various nitrogenous extracts. This liquor may be discharged to the sewers, but it is usually concentrated into what is called "stick," and the stick is mixed and dried with tankage. The residue from steam rendering is processed for recovery of grease and solids. The liquors coming from the pressing operation are settled and skimmed to recover the grease, and the liquors themselves are remixed with the tank water for conversion into stick. The bones from cattle feet are rendered in hot water to recover neat's-foot stock. The water in which the bones are cooked has some pollutional characteristics.

Hide cellar.—The wastes from the hide cellar are similar to those from a slaughterhouse but are extremely small in quantity, though high in salt content.

Hog hair removal.—In the larger plants hair removal is accomplished by a mechanical scraper. The hair is removed, washed, and sold unprocessed,

Survey data, Telfer packing company recirculating filter [1]

	Sept. 22			Sept. 23		
	Raw waste	Septic tank effluent	Final effluent	Raw waste	Septic tank effluent	Final effluent
Total solids p. p. m.	5,042	3,566	1,962	5,058	3,822	1,916
Total volatile p. p. m.	2,762	1,672	460	2,364	1,536	352
Suspended solids p. p. m.	1,160	1,364	[2] 28	420	1,344	[2] 23
Suspended volatile p. p. m.	1,032	940	[2] 18	332	880	[2] 14
5-day B. O. D. p. p. m.	2,200	750	[2] 18	1,750	725	[2] 57

[1] Michigan Engineering Experiment Station Bulletin No. 96.
[2] Corrected for volume difference resulting from the inclusion of 11,200 gallons per day of cooling water in effluent line.

or further processed by boiling in water for 8 to 10 hours with a small amount of caustic soda. The hair is removed from the cooking tank and run through pickers for breaking up the tufts of hair. It is then dried and baled for sale. The scalding vat, wash, and cook waters containing dirt, scurf, and escaped hair are discharged. Some of the smaller packing plants do not produce enough hair to justify its recovery, but dispose of it to farmers with other solid refuse, for fertilizer purposes.

Casing cleaning.—Casings are washed, cleaned of their contents by squeezing or pressing by hand or machine, salted, drained, resalted, and packed for shipment. Trimmings from the casings are rendered to recover grease. The waste waters from the cleaning machines are discharged to catch basins for grease recovery.

Tripe room.—The tripe, or muscular part of the stomachs of cattle, is washed, scalded, scraped, and cooked, after which the fatty layers are scraped off. The wash, scalding, and cooking waters containing grease and suspended matter are discharged into catch basins.

TABLE 4.—*Analyses of major components of waste from hog packinghouse* [1]

	Concentration (parts per million)							
	Solids		Nitrogen		Cl as NaCl	Oxygen consumed	5-day biochemical oxygen demand	pH
	Total	Suspended	Organic	NH_3				
Killing department	1, 840	220	134	6	435	500	825	6. 6
Blood and tank water	44, 640	3, 690	5, 400	205	6, 670	-------	32, 000	9. 0
Scalding tub	13, 560	8, 360	1, 290	40	640	4, 300	4, 600	9. 0
Hog dehairing	1, 540	560	158	10	290	620	650	6. 7
Hair cook water	4, 680	80	586	30	290	-------	3, 400	------
Hair wash water	7, 680	6, 780	822	18	230	1, 680	2, 200	6. 9
Meat cutting	2, 840	610	33	2. 5	1, 620	260	520	7. 4
Gut washer	22, 600	15, 120	643	43	360	-------	13, 200	6. 0
Curing room	26, 480	1, 800	83	12	19, 700	2, 520	2, 040	7. 3
Curing room showers	34, 100	1, 720	255	25	29, 600	875	460	6. 7
Cured meat wash	9, 560	920	109	17. 5	6, 200	950	1, 960	7. 3
Pickle	140, 000	-------	2, 750	37	77, 800	-------	18, 000	5. 6
Sausage and miscellaneous	11, 380	560	136	4	880	460	800	7. 3
Lard department	820	180	84	25	230	200	180	7. 3
Byproducts	4, 000	1, 380	186	50	1, 330	970	2, 200	6. 7
Laundry	18, 620	4, 120	56	5	-------	780	1, 300	9. 6

[1] Iowa Engineering Experiment Station Bulletin No. 130.

TABLE 5.—*Analyses of combined packinghouse wastes* [1]

Number of plants	Concentration (parts per million)				5-day biochemical oxygen demand
	Suspendid solids		Nitrogen		
	Total	Volatile	Organic	NH_3	
28	699	597	116	25	953
4	398	-------	98	------	587
1	467	-------	68	------	550
1	708	613	-------	------	758
1	720	-------	-------	------	955
1	233	195	-------	------	372
1	534	449	71	12	1, 240
1	665	658	167	14	1, 634
Average [2]	645	582	113	24	909

[1] Table taken from Supplement D, Industrial Waste Guides, U. S. Public Health Service, 1945.
[2] Average weighted by plants.

Sausage room.—Process consists of preparing fillings from meat and stuffing the casings. Utensil and floor washes are discharged.

Laundry.—The laundries of the large plants are of considerable size. An analysis of this waste is included with the tabulation of analyses of hog plant wastes in table 4.

Glue stocks.—The manufacture of glue is usually carried out in a separate plant. Glue is a collagenous matter extracted from heads, feet, bones, tendons, and hide trimmings by rendering them in water at different temperatures. The waste consists of wash waters used to wash the raw materials prior to extraction.

Soap.—The manufacture of soaps is confined to some of the largest houses. The average packinghouse produces the inedible tallow and grease sold to the soap manufacturers. The wastes produced

from the manufacture of such greases are covered under rendering.

Fertilizers.—The production of fertilizers has lost some of its importance in the packinghouse with the advent of dry rendering which enables production of higher grade tankages which are used more for stock feed than for fertilizer. The fertilizer industry, once largely a packinghouse operation, has become more the province of the chemical industry, and packinghouse fertilizer stocks are shipped for use by fertilizer plants.

The character of the major components of the waste of a hog packinghouse is indicated in table 4.

Analyses of the combined raw wastes from packinghouses are shown in table 5. Most of these plants are in Chicago.

Pollution Effects

Meat plant wastes are quite similar to domestic sewage in their composition and in their effects upon receiving bodies of water. The danger from pathogenic organisms in packinghouse or slaughterhouse wastes, however, is slight. In the absence of adequate dilution the principal deleterious effects of meat plant wastes are oxygen depletion, sludge deposits, discoloration, and general nuisance conditions.

Remedial Measures

Plant Practices

Various plant practices in more or less common use reduce the quantity or strength of wastes from meat plants. Some of these practices are profitable, at least in the larger plants. Among them are blood recovery, grease recovery, and utilization of tank waters and tankage press liquors. Baffled basins or traps on waste lines are in common use for grease recovery, and the modern designs are very efficient in grease removal. Blood recovery practices vary to some extent. Practically all plants recover substantially all the blood from the killing operations. While a separate disposal of paunch manure is seldom profitable, it is nevertheless desirable. In plants where paunch manure is separately disposed of, a certain amount of the liquid waste reaches the sewers.

No data are available as to the possible reduction in waste load that can be effected by recovery of byproducts, careful segregation of solid wastes, and good housekeeping methods, but the reduction must be considerable. In general, the extent to which waste load from packinghouses is reduced by collection of waste material within the plant depends upon whether the cost of such methods is less than the cost of handling the waste load in a sewage disposal system.

Treatment

Meat plant wastes are amenable to biological treatment in plants of the type in common use for treatment of domestic sewage. The most satisfactory method is to treat them in conjunction with domestic sewage. Trickling filters, particularly of the type developed by Levine and associates, have proved the most successful. Notable among these are installations at Cedar Rapids, Waterloo, Fort Dodge, and South St. Paul. A number of municipal plants treat large amounts of packinghouse wastes with domestic sewage. Examples are in Chicago, where the activated sludge process is used, and Milwaukee and Indianapolis. Daily and seasonal variations in loading may cause difficulty with the activated sludge process where packing plant waste is treated alone or with limited quantities of domestic sewage. This difficulty has been corrected, notably at Sioux Falls, where trickling filters operate in connection with the activated sludge process. Chemical precipitation is used at a number of packing plants and slaughterhouses where less highly purified effluents are required. The operating costs of chemical treatment are high and there is the attendant problem of sludge disposal.

The possibility of discharging the wastes into a municipal sewerage system for treatment at the

municipal sewage treatment plant should be thoroughly investigated before embarking upon the design of separate waste treatment facilities. It is important that meat plant officials discuss and reach agreements with both State water pollution control authorities and appropriate municipal sewage treatment officials before making the final desicison as to treatment and disposal of wastes.

One factor to be considered in treatment of packinghouse wastes in conjunction with domestic sewage is the proper evaluation of charges for treatment. This subject has been studied extensively. The most recent and comprehensive study has been published as ASCE Bulletin No. 2, "Fundamental Considerations in Rates and Rate Structures for Water and Sewage Works."

Chicago experiments.—The most extensive studies of treatment for meat plant wastes were made by the Sanitary District of Chicago through the operation of the Packingtown testing station from 1912 to 1914 and from 1915 to 1918. Other extensive studies of such wastes have been made by Levine and his associates, Halvorsen and others. All of the standard methods of waste treatment have been investigated, and a number of special methods have been developed.

The following is abstracted from a summary of the Packingtown studies by Mohlman.

Treatment processes studies included fine screening, sedimentation, chemical precipitation, trickling filters, and activated sludge.

The results of these extensive studies are as follows:

Screening by rotary wire mesh screen removes coarse materials such as hair, flesh, paunch manure, and floating solids. Frequent clogging of screens necessitated washing with hot water and soda ash. Removals of 9 percent suspended solids on 20-mesh screen and 19 percent on 30-mesh screen were reported. There was no appreciable reduction in biochemical oxygen demand.

Sedimentation, in an Imhoff tank, was found the most satisfactory process for clarification. Chemical precipitation, while removing more suspended solids, produced an excessive volume of sludge which was ill-smelling and hard to dry. Imhoff removals were approximately 65 percent suspended solids, 35 percent biochemical oxygen demand with detention periods of 1 to 3 hours, with a sludge containing 90 percent moisture.

Filtration on trickling filters consisting of 5½ feet of 1¼- to 2-inch stone over 6 inches of 2- to 4-inch stone, at rates varying from 0.6 to 1.0 m. g. a. d., gave satisfactory nitrified effluents which could be well clarified by secondary sedimentation. The filters were reported to give little trouble from pooling, flies, or odors; they unloaded continuously. Removals were 81 percent biochemical oxygen demand (88 percent overall).

Activated sludge gave a satisfactory effluent with 9 hours aeration and 3.5 cubic feet air per gallon. Nitrates ran 5 to 7 parts per million in summer; but in winter it was necessary to increase air rates up to 4 or 5 cubic feet per gallon, and even at this high rate nitrates were not produced. The suspended solids and biochemical oxygen demand removals were higher than those of the settled trickling filter effluents.

Table 6 shows typical and representative analyses of the applied raw waste and the effluents produced.

Double filtration.—The studies by Levine and his associates at Mason City, Iowa, led to the construction in 1929 of a plant providing double filtration to replace an activated sludge plant which had failed due to a greatly increased load and wide fluctuations in the strength and character of the wastes. The plant provided primary clarification with 2 hours' detention, primary filtration at a rate of 3,000,000

TABLE 6.—*Packingtown testing station (Chicago); Results of various treatment processes* [1]

Determination	Effluent (parts per million)				
	Raw waste	Screen	Imhoff tank	Trickling filter	Activated sludge
Ammonia nitrogen	22.0	22.0	29.0	16.0	10
Organic nitrogen	79.0	75.0	60.0	20.0	10
Nitrite nitrogen	.5	.5	.2	2.2	1
Nitrate nitrogen	3.0	3.0	1.7	16.4	5
Oxygen consumed	268.0	240.0	180.0	50.0	----
Chlorine	1,000.0	1,100.0	1,100.0	1,100.0	1,100
Alkalinity	212.0	212.0	240.0	200.0	----
Suspended solids	605.0	515.0	210.0	75.0	30
Biochemical oxygen demand (10-day)	990.0	930.0	630.0	120.0	50

[1] Table taken from Supplement D, Industrial Waste Guides, U. S. Public Health Service, 1943.

gallons per acre per day, on a washable filter 4 feet deep with ½- to 1-inch dolomite filter media, intermediate clarification with 2 hours' detention, secondary filtration at a rate of 1,500,000 gallons per acre per day on an 8-foot deep filter with 1- to 3-inch dolomite filter media, and final sedimentation.

A plant similar to the Mason City plant has been installed at West Fargo, N. Dak. The following data are taken from a description of the plant by Howson. The treatment process includes the following steps: (1) fine screens; (2) grit removal; (3) grease flotation; (4) flocculation; (5) primary settling; (6) washable primary trickling filters; (7) secondary settling; (8) final trickling filters with 2 units which may be operated in series or in parallel; (9) final settling; and (10) discharge to river over aeriating cascades. Although essentially like the Mason City plant, the West Fargo installation includes a number of improvements and changes which have been found desirable as a result of the experience with the earlier plant.

The grit chamber and settling tank each provide 30 minutes' detention and together remove about 90 percent of the settleable solids and 35 to 40 percent of the biochemical oxygen demand. The grease flotation tank provides 15 minutes' detention and is divided into aeration and coalescing compartments by an inclined baffle. The flocculation compartment provides 40 minutes' detention and is equipped with 3 paddle-type flocculators in series. Mechanical flocculation without the addition of chemicals increases the biochemical oxygen demand removal through the tanks by about 5 percent. In order to equalize the flow through the secondary devices, a storage tank with a capacity of 20 percent of the day's flow is provided. The primary filters are 6 feet deep and are equipped with both air and water wash systems. The filter medium is 1- to 2-inch granite, and the operating rate is about 6,000,000 gallons per day. Used wash water flows to a storage tank from which, after settling, the water flows to the secondary clarifier and through the rest of the plant. The filters are washed every 2 or 3 weeks. In the intervening period the wash water settling tank is used for sludge thickening. The primary filters, together with the primary and secondary clarifier, have consistently reduced the biochemical oxygen demand of the raw wastes from 1,000 parts per million to 250–350 parts per million when loaded at rates of 5,000 to 6,000 pounds of biochemical oxygen demand per day. Secondary settling is in a Dorr clarifier with a detention period of 1 hour. The final filters are conventional trickling filters 6 feet deep and dosed at a rate of about 1,400,000 gallons per acre per day when operated in parallel. The final filters are ordinarily operated in parallel. Overall reductions of more than 95 percent of the biochemical oxygen demand have been accomplished consistently.

A large treatment plant has recently been constructed at South St. Paul, Minn., to treat a large volume of packing plant sewage. This treatment plant has washable filters.

High rate filtration.—High rate filtration has been successfully applied in some instances. On the other hand, medium and standard rate filters are successfully treating meat packing waste, as such, or in mixtures with domestic sewage.

A high rate recirculating filter was constructed at the Telfer Packing Co., Owosso, Mich., during the winter of 1941 and 1942.[1] The results are of interest since they demonstrate the adaptation of this filtration process to the treatment of slaughterhouse wastes. The plant is typical of a large number of comparatively small slaughter-houses and packing plants that are spread through the rural sections of much of the country. It is located on the outskirts of Owosso, and does not have access to the municipal sewer system. The treatment plant consists of a septic tank, high rate filter, settling tank, and holding tank. The wastes pass through the septic tank and then to the holding tank. From the holding tank the wastes are pumped to the filter. The filter effluent flows to the settling tank where the solids built up by the filter are removed. From the settling tank the wastes pass into a weir box where a portion equal to the rate of raw waste flow is discharged to the effluent sewer. The remainder enters the holding tank for recirculation to the filter after mixing with the raw wastes coming from the slaugh-

[1] Michigan Engineering Experiment Station Bulletin No. 96.

terhouse. The table below shows loadings and operating data collected during a two-day study of the plant.[1]

Loadings

	Sept. 22	Sept. 23
Septic tank:		
Volume, gallons per day	4, 200	3, 070
B. O. D. influent, pounds per day	77. 0	44. 8
B. O. D. effluent, pounds per day	26. 3	18. 5
B. O. D. removed, pounds per day	50. 7	26. 3
B. O. D. removed, percent	66. 1	58. 8
Filter:		
Volume, gallons per day	15, 400	14, 270
Rate, m. g. a. d	20	20
Times recirculated	4. 5	4. 9
B. O. D. influent, pounds per day	26. 3	18. 5
B. O. D. effluent, pounds per day	. 6	1. 5
B. O. D. removed, pounds per day	25. 7	17. 0
B. O. D. removed, percent	97. 6	92. 0
B. O. D. loading, cubic foot pound	35. 0	50. 0
B. O. D. loading, pounds per cubic yard	. 77	. 54
Overall B. O. D. removal, pounds per day	76. 4	43. 3
Overall B. O. D. removal, percent	99. 2	96. 6

Chemical precipitation.—A number of precipitants have been used in various plants treating packing house wastes. The use of superchlorination for the precipitation of proteins as practiced at Austin, Minn., has been abandoned because of cost, the toxicity of the sludge, and the necessity of excluding much of the waste from the treatment processes.

At Phoenix, Ariz., a packing plant uses ferric chloride made from wire and chlorine. Biochemical oxygen demand reductions from 1,448 to 188 parts per million and suspended solids reductions from 2,975 to 167 parts per million are obtained, using 1,000 pounds of wire and 1,150 pounds of chlorine per million gallons. Operating costs were at one time reported to be $68 per million gallons. However, the effluent was sold for irrigation, grease was recovered, and sludge was utilized, reducing the net cost to about $25 per million gallons.

At Madison, Wis., chemical precipitation using lime as a coagulant proved successful in the removal of substantial quantities of B. O. D. and solids but has been abandoned, due to the cost of the large quantities of chemical required and the excessive amount of solids remaining for disposal.

Treatment with municipal sewage.—Since meat plants are concentrated in the larger cities, the commonest method of treating their wastes is in municipal treatment plants. Chicago is the largest center of meat packing in the world, and the wastes from these establishments are being treated successfully by the activated sludge process. Other cities treat varying amounts of meat plant wastes by plain sedimentation, trickling filters, activated sludge, and combinations of these methods. Pretreatment by screening and plain sedimentation of packinghouse wastes prior to admission to city sewers is required in a number of places where the municipal plants are inadequate in capacity. Treatment beyond these steps prior to admission to the city sewers is rarely required.

At Sioux Falls, S. Dak., where packinghouse wastes make up about 76 percent of the total waste load, a municipal treatment plant including chemical precipitation, trickling filters, and activated sludge has been successful in producing a highly purified effluent. Experiences in treating these wastes have been described by Bragstad and Bradney. The following data are abstracted from their article. An earlier trickling filter plant operated satisfactorily with overall removals of 80 to 85 percent of the biochemical oxygen demand and suspended solids but the residual biochemical oxygen demand polluted the receiving stream seriously. After considerable experimental work, the plant was remodeled to provide chemical precipitation of the packinghouse wastes, separate sedimentation of the domestic sewage, followed by trickling filters, activated sludge treatment (about 5 hours aeration), and final sedimentation. Considerable difficulty with floating sludge in the final tanks was experienced due to denitrification of the effluent. This was controlled by regulating the dissolved oxygen content in the aerator within the narrow range which would prevent both floating sludge and bulking. In order to do this effectively it was necessary to overcome the wide fluctuations in flow to the aerator. This was done by regulating the rate of pumping from the filter to the aerator. Although the filter effluent backed up in the filter gallery, there was no detrimental effect on the efficiency of the units. The following table shows the average results during a 12-month period (January–December 1950) when the wastes were separately clarified, filtered at 4.0 m. g. a. d. during the day and 2.0 m. g. a. d. at night, aerated, and settled. No chemicals were used in the flocculation.

[1] Michigan Engineering Experiment Station Bulletin No. 96.

TABLE 7.—*Results of treatment of packinghouse waste and domestic sewage at Sioux Falls, S. Dak., January–December 1950* [1]

	Suspended solids		5-day biochemical oxygen demand	
	Parts per million	Percent removal (overall)	Parts per million	Percent removal (overall)
		Percent		*Percent*
Packinghouse, raw [2]	851. 0		1, 218	
Domestic, raw	301. 5		303. 6	
Combined, raw	550. 0		716. 0	
Packinghouse primary effluent	364	57. 2	646. 6	47. 0
Domestic primary effluent	107	64. 5	135	55. 6
Combined primary effluent	224	59. 3	367	48. 6
Secondary filter effluent	146	73. 5	112. 7	84. 0
Final effluent	17. 2	96. 8	18	97. 5

[1] Source, American Meat Institute.
[2] Packinghouse waste screened and settled briefly before discharge to municipal sewers.

Information on other treatment methods and additional information on the methods discussed above can be secured from the technical literature. For an extensive bibliography containing 190 references, see listing No. 8 in the following bibliography.

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